AUSTRALIAN ACANTHOCEPHALA, No. 2.

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Sphaerechinorhynchus rotundocapitatus (Jnstn.), n. gen.

Figs. 1 to 34.

This parasite occurs fairly commonly in the rectum and lower part of the intestine of the black snake, *Pseudechis porphyriacus* Shaw, in New South Wales, Victoria and Southern Queensland, and has been recorded recently from South Australia (Johnston and Deland 1929). It was originally described (Johnston 1912, 83) under *Echinorhynchus,* a genus which has since been considerably subdivided.

The body is firm and roughly cylindrical, white in life, but creamy, or even pinkish, in preserved material. The cuticle is smooth in extended, and transversely wrinkled in contracted, specimens.

The females are larger and, when mature, range from 30 to 37 mm. in length. One young individual was only 18 mm. The body is wide (4 to 5 mm. in diameter) for the anterior two-thirds, and tapers to 1·5 to 2·0 mm. The posterior extremity is bifid, the genital aperture lying slightly below the apex of the cavity between the two lobes (figs. 30, 31).

The males range from 18 to 23 mm. in length and are much less tapering than the females. The width anteriorly is about 3 mm., and posteriorly about 2 mm. The form of the posterior end varies with the degree of extension. In one specimen the copulatory bursa was everted, appearing as a delicate, white, bell-shaped structure of the form shown in figs. 28 and 29.

The above measurements were taken from material preserved in formalin and containing a large number of individuals. In specimens preserved in spirit, and obviously much contracted, the lengths were—female, 15 mm.; males, 12 and 14·5 mm.

The proboscis is nearly spherical, measuring from 0·7 to 0·85 mm. across, and bears 18 longitudinal rows of hooks with alternately 6 and 7 in a row, making 117 in all (fig. 1). Each hook consists of a strong backwardly projecting outer spine and a large basal portion embedded in the musculature of the proboscis. They are largest at the apex, becoming very much smaller at the base. Three typical hooks, the apical three of their row, are shown in fig. 3. There is a short neck-like region followed by a somewhat wider collar connecting it with the body (fig. 2). The body wall is composed, as usual, of a cuticle, a thick subcuticula, and two layers of muscle fibres, an external circular and an internal longitudinal (figs. 9, 12). The subcuticula shows all the areas generally present. A region of radial striations lies immediately below the cuticle, which it slightly exceeds in thickness. Beneath this is a distinct layer of mingled circular, tangential and radial fibrils, divided into six to eight strata by the circular fibrils. This arrangement is less pronounced than that indicated by Saefftigen (1885), for *Echinorhynchus proteus* Westr., which is now usually known as *Pomphorhynchus laevis* Muller, and recently by Harada for *Rhadinorhynchus katsuwonis.* Below this layer is one of radially-arranged fibrils in which travel the channels of the lacunar system. The subcuticula is bounded by a thin but definite limiting membrane. The nuclei of the subcuticula are typical of those of the whole body (figs. 7, 10). They are not situated in the fibrous portion of the subcuticula nor in the walls of the lacunae, as figured by Hamann for *Ech. echinodiscus* Dies

(= *Gigantorhynchus echinodiscus)*, but are suspended in the middle of the lacunae by strands of tissue. Saefftigen (pl. 3, figs. 1, 3) indicates them in this position but without any supporting fibrils. The nuclei, which measure 0·02 to 0·03 mm. in their longer axis, are irregular in outline and contain numerous very obvious nucleoli, of which there may be as many as a dozen, ranging in size from the smallest which are mere dots under oil immersion, to a maximum of 0·0075 mm. (fig. 10). The variations in size and shape of the nuclei, and in number of the nucleoli, are greater in the subcuticula than elsewhere in the body.

The lacunar system consists of two definite longitudinal canals in addition to very numerous smaller channels of rather irregular outline, which form a close

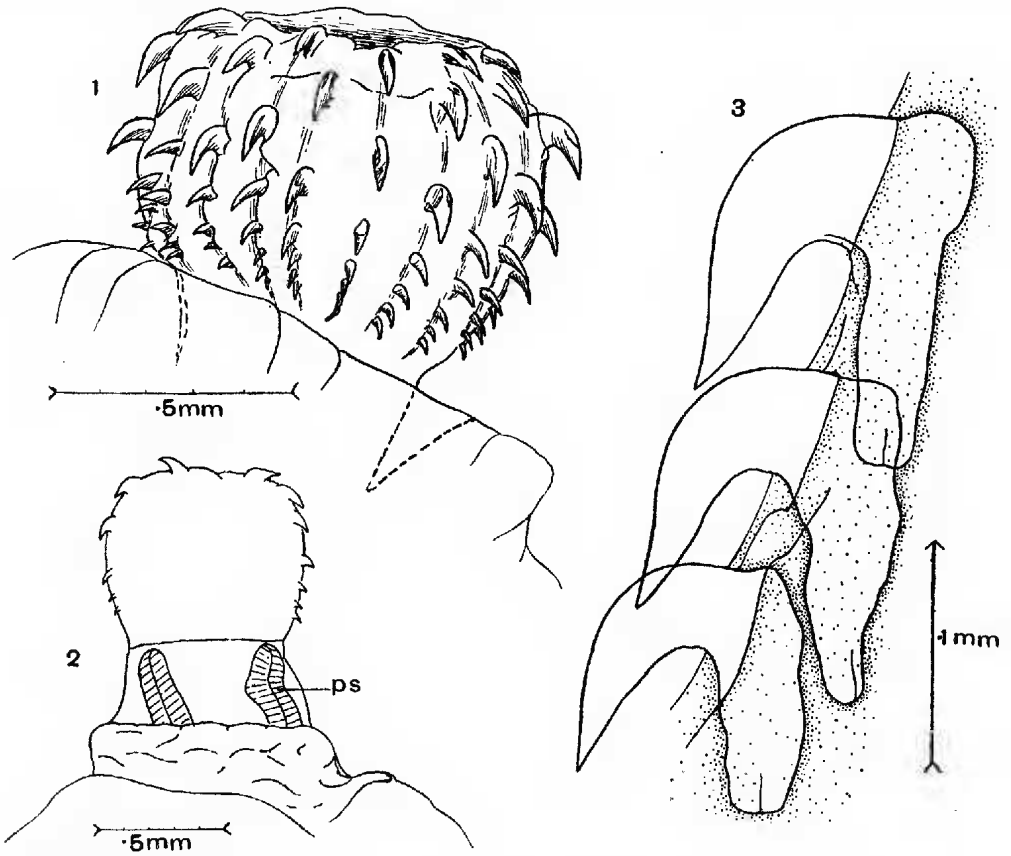


Fig. 1.—Proboscis.
Fig. 2.—Outline of anterior end indicating insertion of proboscis sheath.
Fig. 3.—Three most anterior hooks of one longitudinal row.

network throughout the subcuticula (fig. 8). The canals in the lemnisci are single and centrally situated (fig. 15).

Beneath the subcuticula lie layers of circular and longitudinal muscle fibres. Within the spaces surrounding the bases of these a certain amount of a granular coagulum, which stained deeply with haematoxylin, was sometimes found. A similar substance occurred in spaces in the proboscis (fig. 18) and male genital organs, but such material was not seen in the lacunar system.

The proboscis sheath is a double-walled muscular sac inserted at the base of the proboscis (fig. 2). Its length varies from 2·5 to 2·7 mm., and its maximum width from 1·05 to 0·75 mm. The central region is occupied by four large, branching retractor muscle cells, which are attached to the muscular wall of the

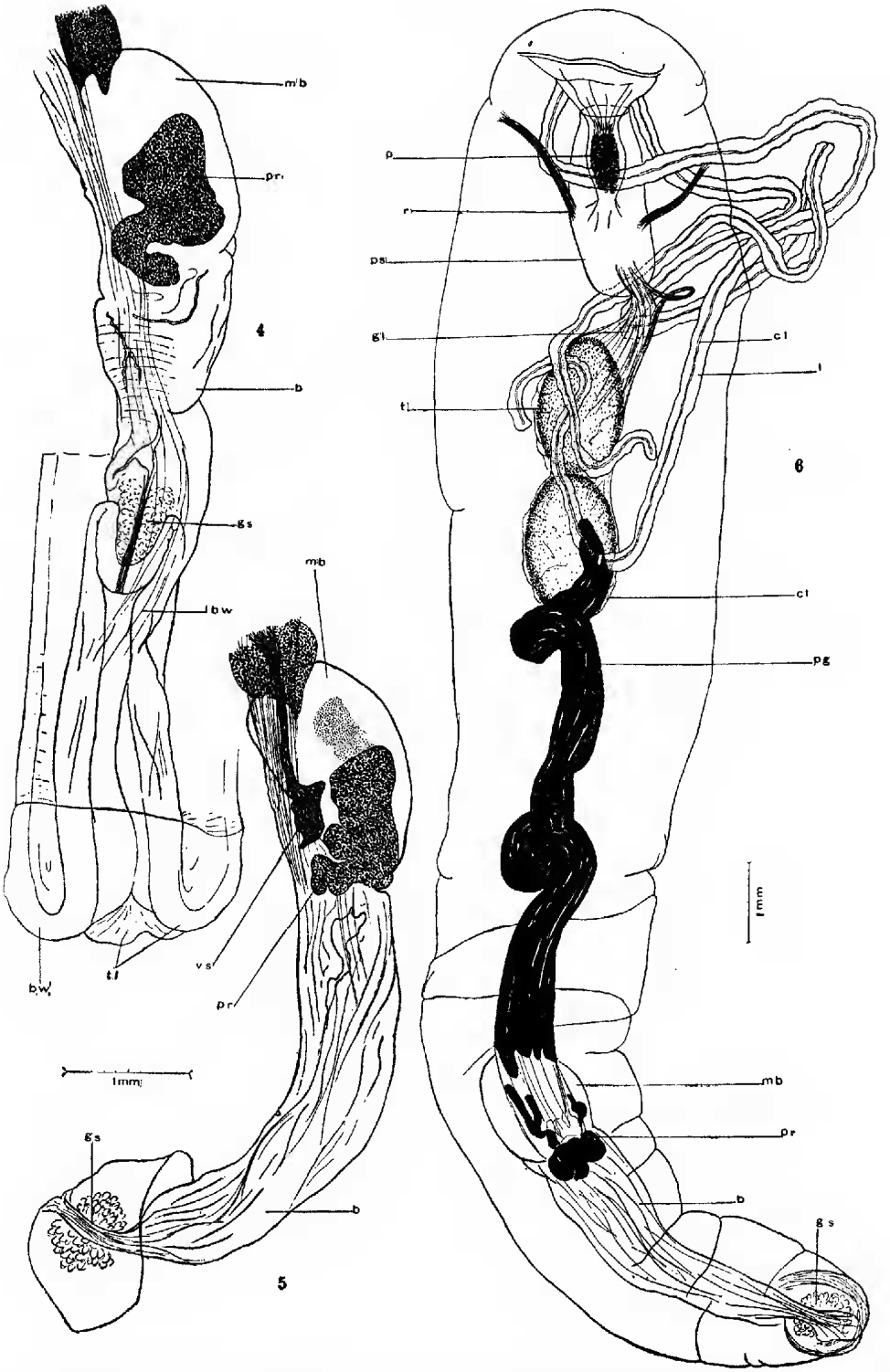


Fig. 4.—Portion of posterior end of male, showing end of body deeply invaginated.
Fig. 5.—Ditto, showing genital sphincter in terminal position. Drawn to same scale as fig. 4.
Fig. 6.—Entire male, showing anatomy.

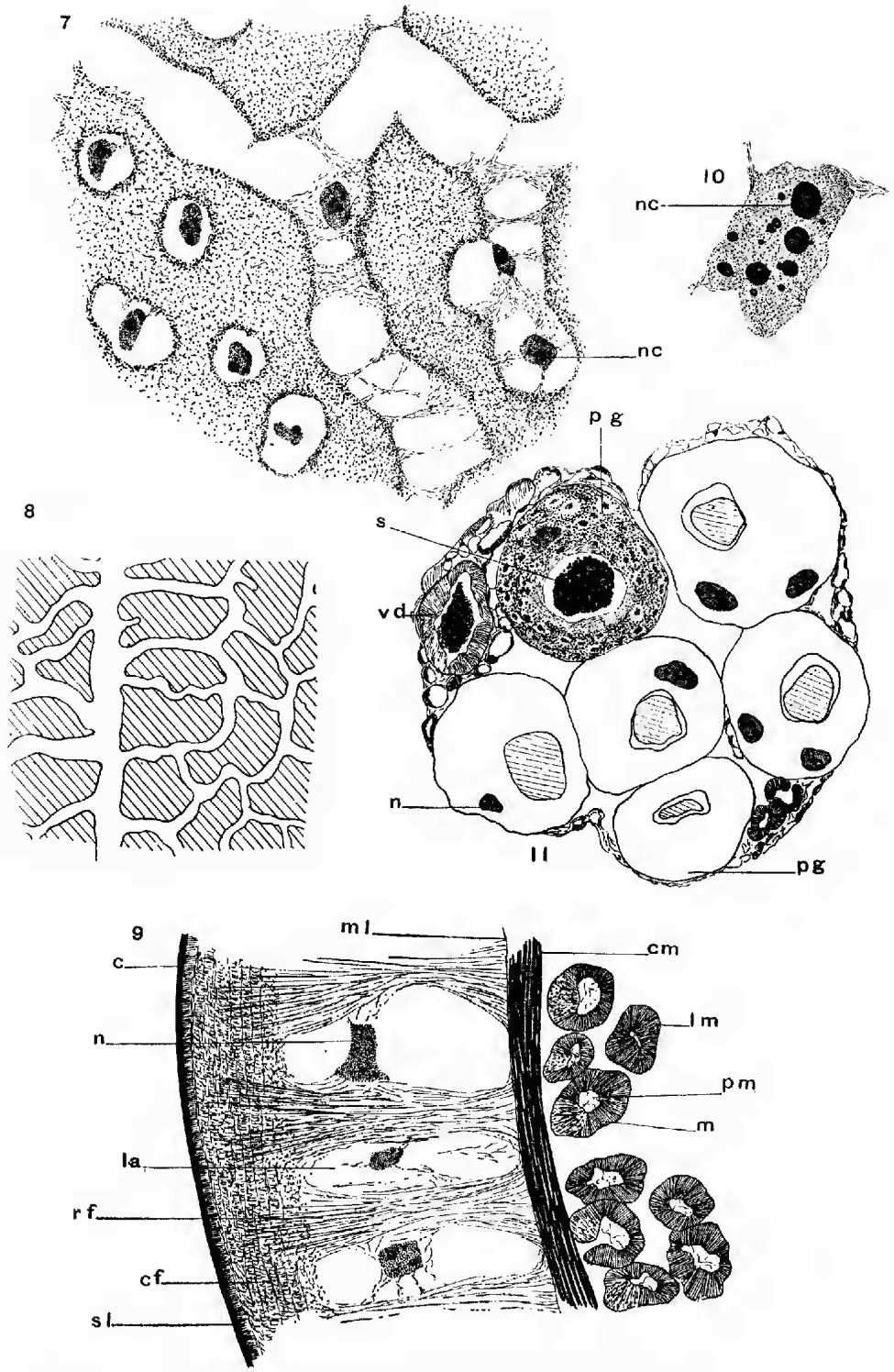


Fig. 7.—Lacunar system of body wall (from tangential section).
Fig. 8.—Lacunar system of part of body viewed as a transparent object.
Fig. 9.—Portion of T.S. body wall.
Fig. 10.—Nucleus from subcuticula.
Fig. 11.—T.S. of prostate glands and vas deferens.

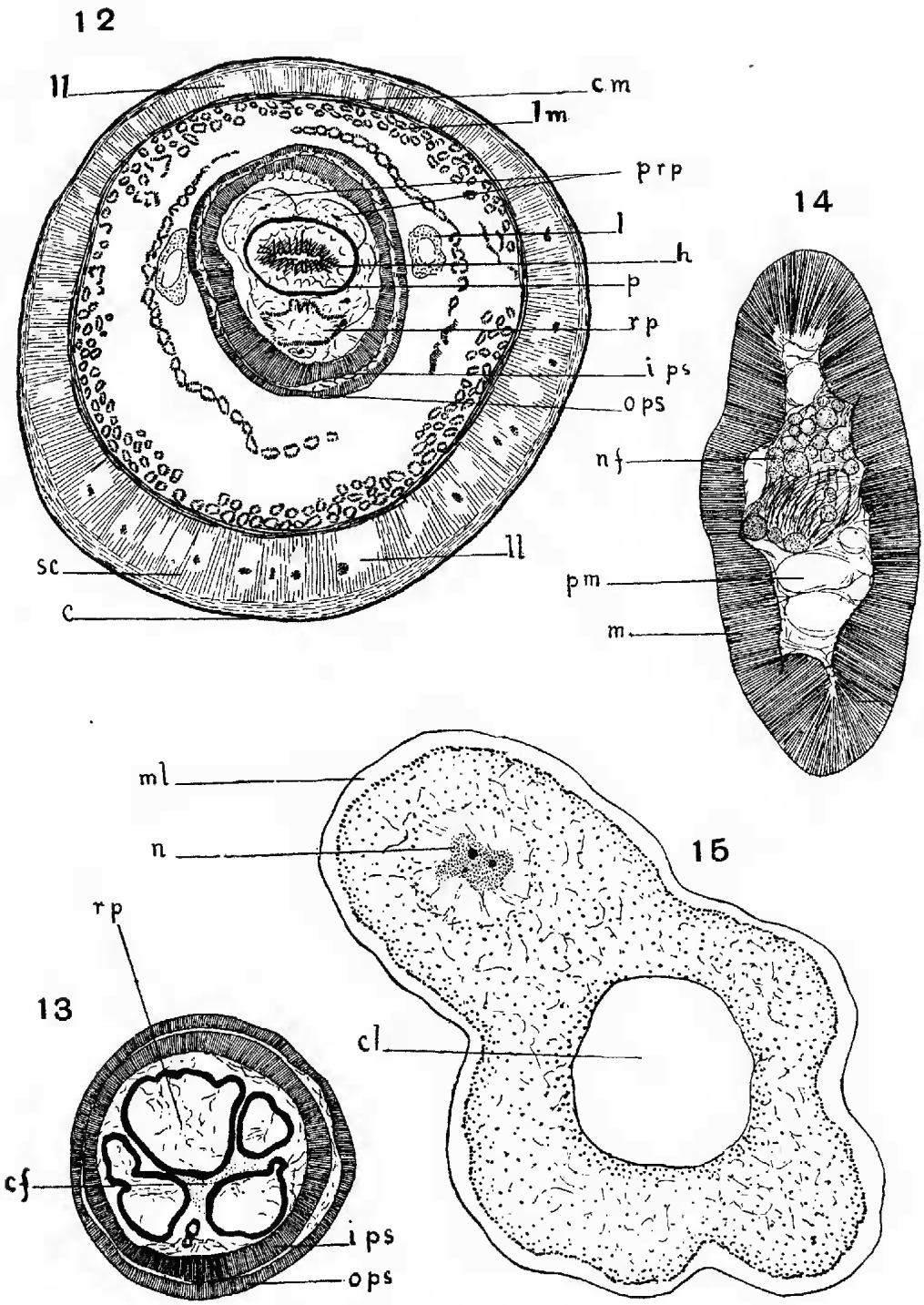


Fig. 12.—T.S. body at level of introverted proboscis.
Fig. 13.—T.S. proboscis posterior to fig. 12.
Fig. 14.—T.S. retinaculum, showing enclosed nerve fibres.
Fig. 15.—T.S. lemniscus.

proboscis in front and the inner proboscis sheath at its base. The protoplasmic portion of these cells lies anteriorly, surrounding the retracted proboscis (fig. 12). These cells are shown in transverse section in fig. 13, and two of them in longitudinal section in fig. 18.

The proboscis ganglion is situated eccentrically in the space between the four large retractor muscle cells (fig. 18), somewhat in advance of the mid-length of the proboscis sheath. It consists of a comparatively small number of cells (fig. 16), and does not show as marked a differentiation into a peripheral layer of nerve cells and a central mass of fibres or supporting tissue, as that described

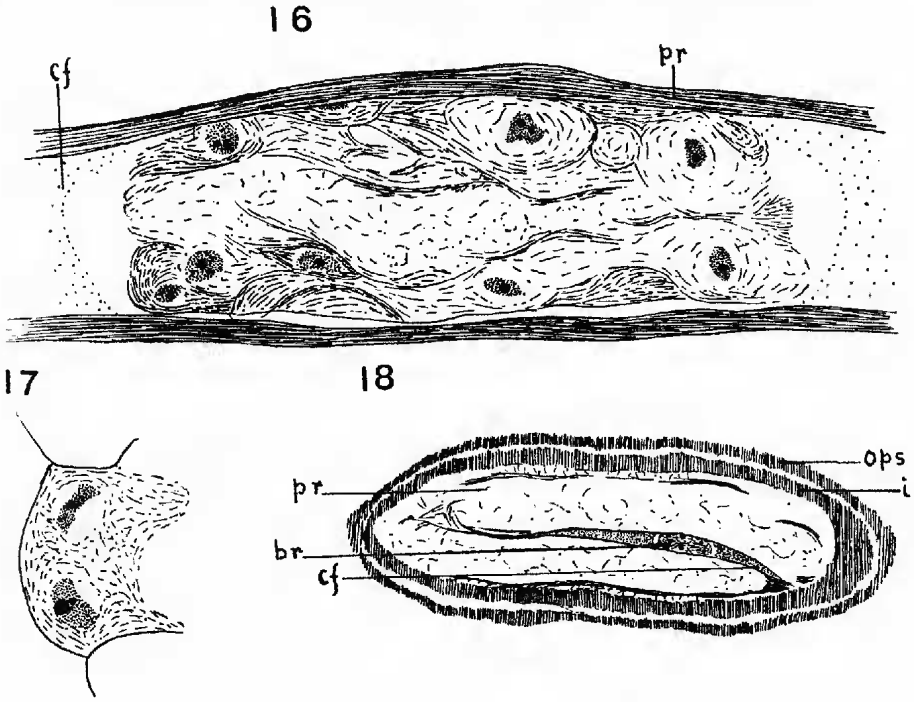


Fig. 16.—L.S. ganglion.
Fig. 17.—Cell (? supporting) from ganglion.
Fig. 18.—L.S. proboscis, showing situation of ganglion; one-tenth magnification of figs. 16, 17.

by Hamann and Saefftigen. It is possible that some of the nuclei observed in the ganglion belong to a syncytial supporting tissue similar to that of the subcuticula, as in two or three cases it was not possible to observe any cell boundary between neighbouring nuclei (fig. 17).

The retinacula arise from the sides of the proboscis sheath, about a millimetre from its posterior end, and pass obliquely forwards to the body wall. In transverse section, each is seen to be composed of a muscular sheath consisting of one long muscle cell which encloses a bundle of nerve fibres (fig. 14).

The two lemnisci which arise at the junction of the proboscis sheath and the general body wall are exceedingly long and narrow, their lengths in a male specimen being 17 and 18 mm., respectively, with an average width of 0·3 mm. Their ground tissue, as seen in transverse section (fig. 15), resembles that of the innermost layer of the subcuticula. There is a distinct, relatively thick, external limiting membrane. The single central lacuna of each appears to be more definitely bounded by a delicate membrane when compared with those of the body wall. Each lemniscus has numerous nuclei, especially towards the anterior end.

In both sexes the genital ligament arises from the posterior end of the proboscis sheath and extends backward through the entire body length. Several

strands of muscle fibres pass from it to the body wall at the posterior end. The ligament itself is composed of a few muscle fibres embedded in a filmy protoplasmic strand.

Male System.

The two oval testes, measuring about 0·5 by 0·3 mm., lie one behind the other in the anterior third of the body. Each is enclosed in a capsule formed by the genital ligament, and from the posterior end of each capsule there arises a single vas efferens. There are six very long, narrow prostate glands whose length in the specimen measured was 12 mm., the diameter of each being about 0·1 mm. These glands commence at about the level of the posterior testis and pass backward, side by side, within the genital ligament. In section they are irregularly rounded, with an approximately central lumen, filled with a granular and strongly eosinophil prostate secretion. The surrounding syncytial tissue contains numerous typical nuclei in a fibrous matrix. Small granules, and groups of granules, are scattered through this matrix, but the area immediately surrounding the lumen is comparatively clear (fig. 11).

The vasa efferentia travel separately within the ligament for about two-thirds the length of the prostate glands, when they unite to form a single vas deferens. The latter, which shows one or two small swellings along its course, passes backward to the apex of the large muscle-sac or markbeutel, where it expands to form a club-shaped vesicula seminalis. From the latter a convoluted ductus ejactulatorius passes through the tissue of the median lobe of the bursa to the male opening.

At the apex of the markbeutel the prostate glands join to form a single muscular prostate duct. In most of the preparations examined this was in a contracted state and contained no secretion, so that it was indistinguishable in whole mounts from the strand of muscle passing from the base of the markbeutel to the body wall and overlying it. This duct opens into a large bilobed prostate reservoir which envelopes the vesicula seminalis and extends laterally on both sides of the markbeutel. At its base the reservoir opens into the ductus ejactulatorius. These structures are shown in a reconstruction in fig. 21, and the relations of the vesicula seminalis, prostate reservoir and ejaculatory duct, in more detail, in fig. 20. No genital ganglion was observed.

The copulatory bursa is a large thin-walled structure which, when withdrawn within the body, is very much folded and puckered. It is lined by a thin cuticle, but there are no lacunae in its subcuticula. At the posterior end the wall of the bursa is continuous with that of the posterior or genital sphincter. The latter is a single muscle cell with a peculiar "frothy" protoplasm surrounding a strongly cuticularised, narrow, winding tube which forms the external genital opening when the bursa is retracted; when the latter is everted it protrudes through this aperture as a bell-shaped organ with a pronounced thickening of part of the wall forming a kind of central lobe or fold projecting into its lumen, while the markbeutel and associated structures become approximated to the inner side of the genital sphincter, and the actual aperture of the male duct becomes carried forward through the sphincter and lies within the everted bursa. In many specimens, not only is the bursa retracted, but as much as three or four millimetres of the body wall may be invaginated, so that the genital sphincter comes to lie at a corresponding distance from the posterior end of the specimen. As a result, there are three possible positions of the male complex, with intermediate connecting stages. Fig. 4 shows the arrangement in a state of extreme retraction, as does the section in fig. 19, where the pushing down of the sphincter into the apex of the invaginated region causes it to simulate a penis. Figs. 5 and 6 and the reconstruction shown in fig. 21 indicate the bursa retracted but with the sphincter terminal; while figs. 28, 29 and the section in fig. 20 show the bursa everted through the sphincter.

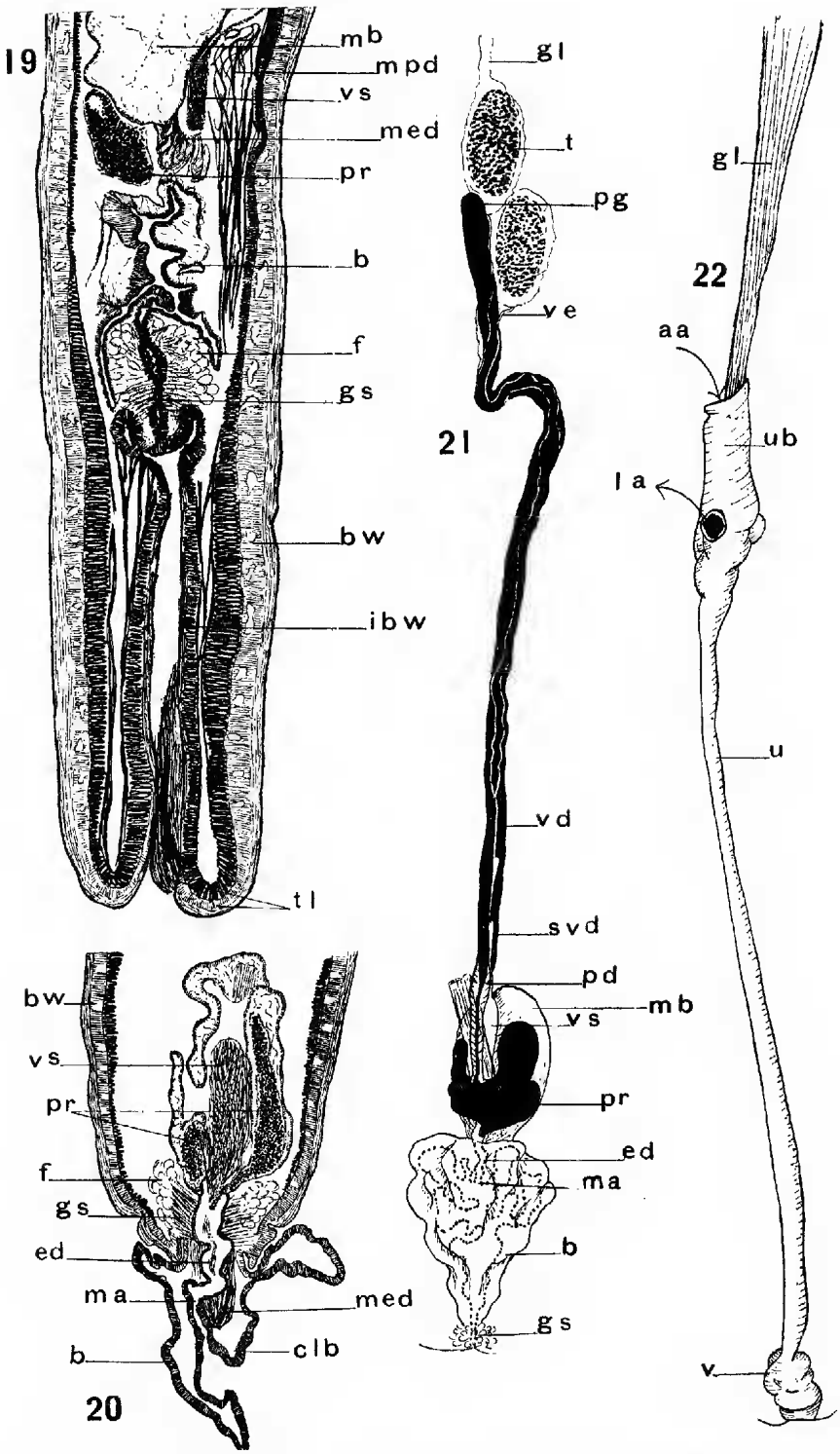


Fig. 19.—L.S. posterior end of male, showing genital sphincter and invaginated body wall.
Fig. 20.—Ditto, somewhat diagrammatic, with bursa extruded.
Fig. 21.—Reproductive system of male, greatly folded walls of bursa indicated by dotted line.
Fig. 22.—Reproductive system of female.

Female System.

In the gravid female the uterine bell, uterus and vagina together measure about 4 mm. in length. The bell consists mainly of one large muscle cell enclosing a cavity into which the genital ligament passes to become attached at the base. There are, in addition, a few much smaller cells forming the posterior region of the bell. Besides the wide anterior opening there are two ventro-lateral apertures leading to the body cavity, each within a lateral muscle cell (fig. 23). From the cavity of the bell two other openings, each within its own lateral muscle cell, lead into the uterus, their position being shown in figs. 24 and 25. This arrangement is essentially similar to that described by Kaiser (1893, pl. 7, figs. 11-16; pl. 8, figs. 2, 37), as occurring in five different species, which have since been allotted to *Acanthocephalus, Macracanthorhynchus, Corynosoma* and *Bolbosoma*. The uterus is a long, narrow tube with muscular walls, and is usually filled with eggs. In the short, swollen vagina which succeeds it, two sphincters, an anterior and a posterior, can be recognised. Investing the lower tenth of the uterus is a pair of elongate cells, probably glandular, lying between the lumen and the muscle cell of that portion of the duct—in other words, these two cells are actually enveloped by the terminal muscle cell of the uterus. Then follows a similar, though very much smaller, cell lying between the muscle cells of the vaginal sphincter and the lumen of the vagina, and actually surrounding the latter. This is succeeded by a large cell, apparently of the same nature as the others, surrounding the female aperture. The last-mentioned cell differs from the others in form, since it possesses a transverse diameter greater than its length and approximately the same as that of the mass of sphincter cells surrounding the preceding portion of the vagina (fig. 26).

Eggs from the uterus range from 0·07 to 0·087 mm. in length, and from 0·025 to 0·027 mm. in diameter. There are three shells, of which the middle one is constricted near each end to form a polar pouch which measures about one-seventh its length. All eggs observed in the uterus were in the two-celled stage (fig. 27).

In figs. 32, 33, 34, two individuals are indicated in copula. These were cleared in methyl salicylate, and some details were observed. The bursa was seen to have been protruded through the genital sphincter, carrying with it the mass of tissue which projects into the cavity of its bell and contains the ejaculatory duct (cf. fig. 20). This projection fitted into the latero-terminal depression of the female, while the end of the latter was surrounded very closely by the bursa.

Systematic Position.

In 1911 Lühe restricted the old genus *Echinorhynchus* very considerably, after separating off from it a number of species which he allotted to new genera, *Plagiorhynchus* being amongst them. He mentioned that the species retained were parasitic in the intestine of fish, and Van Cleave (1923, p. 185) has apparently adopted the same view. *Plagiorhynchus* was erected to include related parasites of birds which differed from *Echinorhynchus,* sensu stricto, in possessing long finger-like lemnisci, a more or less oval body, and eggs with characteristic polar swellings. This genus is regarded by Van Cleave and Travassos (1926) as valid, but Southwell and Macfie (1925, 177) quote it as a synonym of the latter.

The species from the black snake possesses some well-marked characters, such as the short, spherical proboscis, the exceedingly long lemnisci, the anterior position of the testes, and the very long, narrow, tubular prostate glands, while the eggs are intermediate in form between those of *Echinorhynchus* and *Plagiorhynchus*. These differences appear to us to be of sufficient value to justify generic separation. We therefore propose to erect a new genus, *Sphaerechinorhynchus,* for which the following diagnosis may be offered:—Echinorhynchidae; near *Echinorhynchus* and *Plagiorhynchus* (as defined by Lühe and Van Cleave);

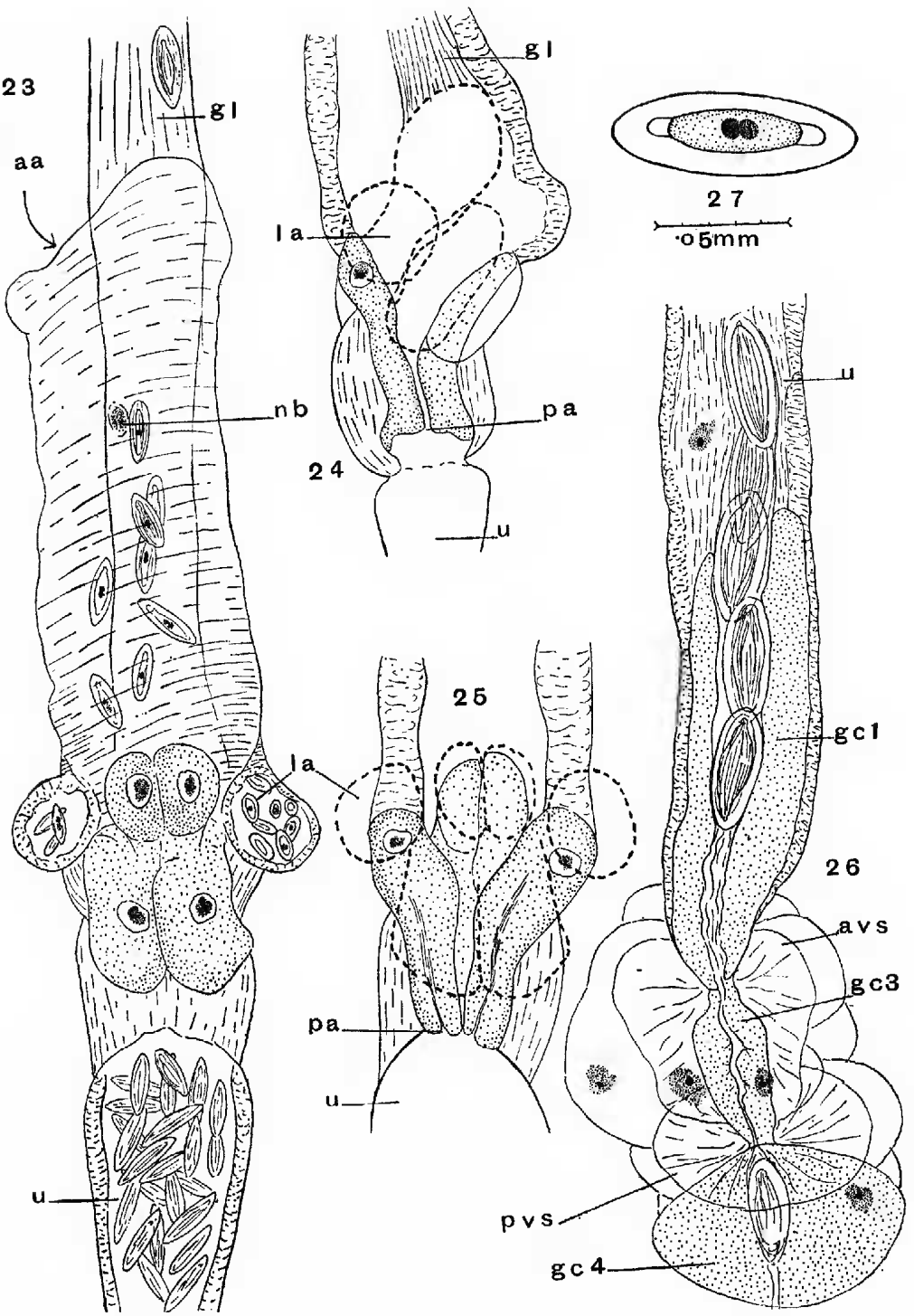
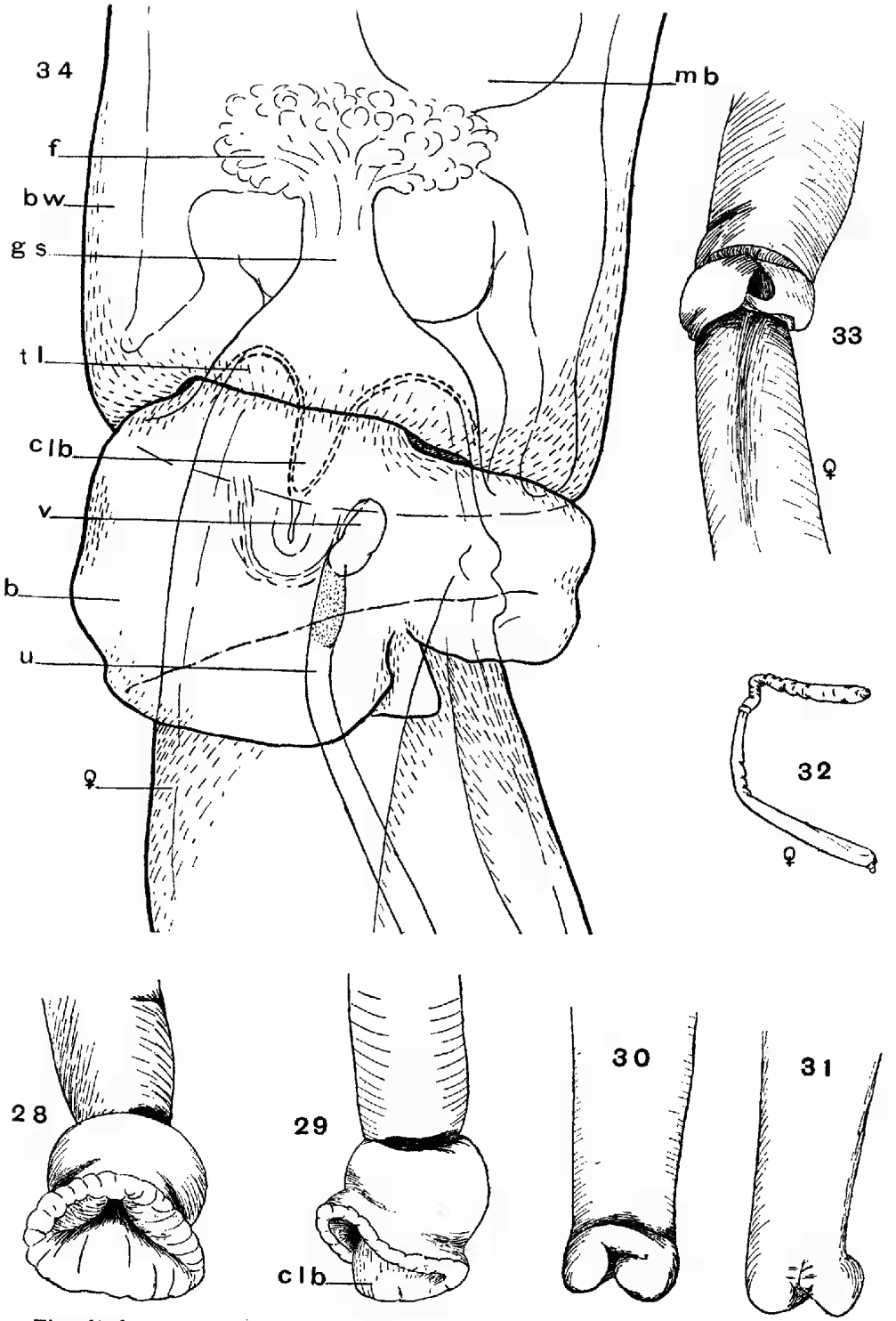


Fig. 23.—Uterine bell.
Fig. 24.—Lateral view of bell in optical section, dotted lines indicate cells shown in fig. 23.
Fig. 25.—Face view of bell in optical section. Figs. 23, 24, 25 are at same magnification.
Fig. 26.—Posterior end of uterus and vagina.
Fig. 27.—Egg.



Figs. 28, 29.—Front and lateral views of everted bursa.
Figs. 30, 31.—Ditto of posterior end of female.
Fig. 32.—Two individuals in copula, about natural size.
Fig. 33.—Ditto, posterior end of each, magnified.
Fig. 34.—Ditto, cleared and viewed as transparent objects, more highly magnified.

small to medium size; body devoid of spines; proboscis short, more or less spherical, with numerous hooks diminishing in size posteriorly and possessing simple roots; numerous small nuclei in subcuticula; proboscis sheath double-walled and inserted at base of proboscis; ganglion near middle of proboscis sheath; retinacula arising from side wall of sheath; lemnisci relatively very long, more than two-thirds the length of body; testes in anterior third of body; prostate glands, six, very long, narrow, tubular. Type, *S. rotundocapitatus* (Johnston 1912) Johnston and Deland 1929, from the black snake, *Pseudechis porphyriacus*.

Explanation of Lettering.

aa, Anterior aperture of uterine bell; avs, anterior vaginal sphincter; b, bursa; br, brain; bw, body wall; c, cuticle; cf, circular fibrils; cfl, coagulated fluid; cl, central lacuna; clb, central lobe of bursa; cm, circular muscle; ct, capsule of testis; ed, ejaculatory duct; f, "frothy" protoplasm of genital sphincter; gc 1, gc 3, gc 4, gland cells of the vagina; gl, genital ligament; gs, genital sphincter; h, hook; ibw, invaginated body wall; ips, inner proboscis sheath; l, lemniscus; la, lacuna; lab, lateral aperture of uterine bell; ll, longitudinal lacuna; lm, longitudinal muscle; m, contractile part of muscle cell; ma, male aperture; mb, markbeutel; med, muscular tissue surrounding ejaculatory duct; ml, limiting membrane; mpd, muscular wall of prostate duct; n, nucleus; nb, nucleus of large muscle cell of uterine bell; nc, nucleolus; nf, nerve fibre; ops, outer proboscis sheath; p, proboscis; pa, posterior aperture of uterine bell; pd, prostate duct; pm, protoplasmic part of muscle cell; pr, prostate reservoir; prp, protoplasmic part of retractor muscles; ps, proboscis sheath; pvs, posterior vaginal sphincter; rp, retractor muscle of proboscis; s, prostate secretion; sc, subcuticula; sl, striated layer; svd, swelling on vas deferens; t, testis; tl, terminal lobes of body wall; u, uterus; ub, uterine bell; v, vagina; vd, vas deferens; ve, vas efferens; vs, vesicula seminalis.

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